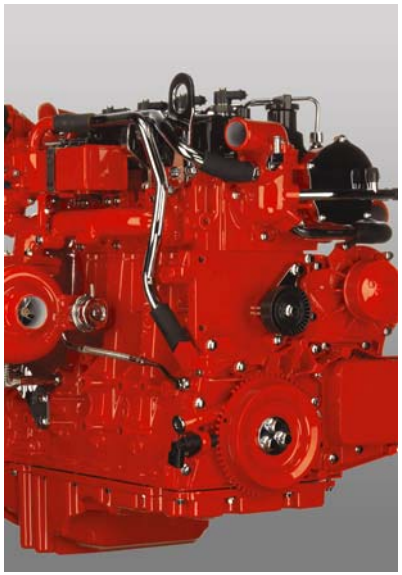
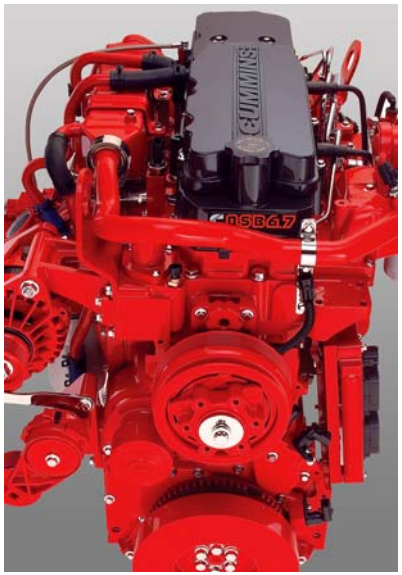
CM2350 Electronic Controls

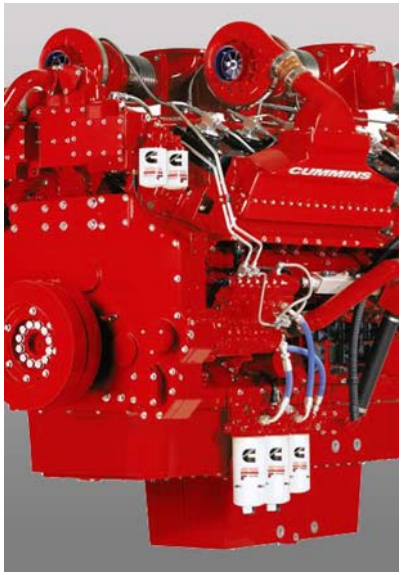
ISB6.7 CM2350 B101

ISL9 CM2350 L101

VERSION 1.1







CM2350 Control System Overview

ECM

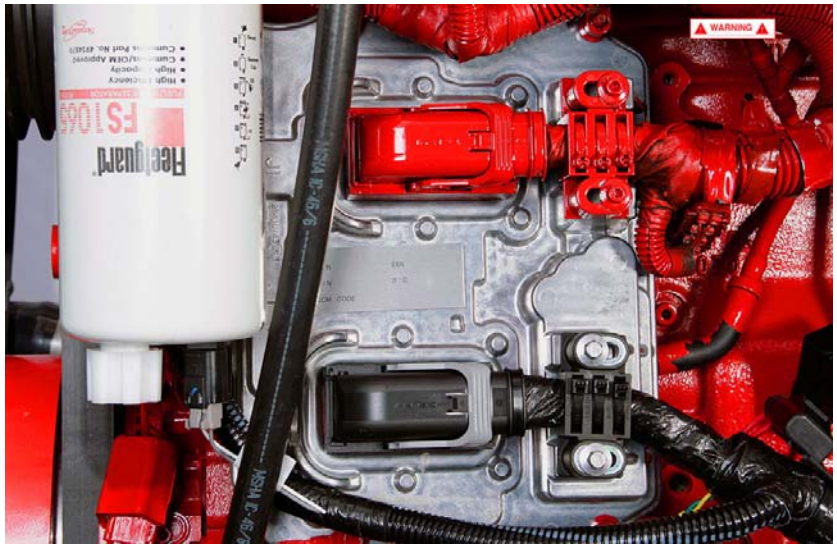
ECM Inputs

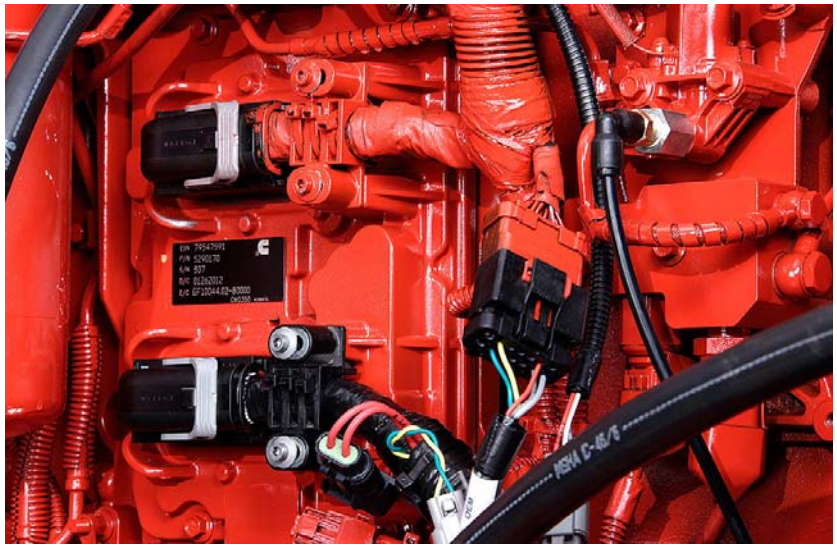
ECM Outputs

Engine tests

Troubleshooting

CM2350 ECM





- Identification
- Mounting Locations (B, L, & X)
- Cooling Strategies
  - Air on ISB6.7, ISX12
  - Fuel on ISL9
  - Fuel on ISX15
- Battery supply & return integrated into the OEM 96 pin connector
- Integrated Aftertreatment DEF Dosing control
- More Datalinked sensor Options
- 96 way connector service

FAULT CODES BASICS

Fault Codes Types

All Fault codes could be categorized and troubleshoot in following categories:

- Electrical failure
  - Inputs
  - Outputs
- Mechanical failure / conditions / response
- ECM Logical Faults
- Communications Faults

Fault Codes Types

Electrical Failure

- INPUT Components
  - Voltage Above Normal, or Shorted to High Source
  - Voltage Below normal, or Shorted to Low Source
- OUTPUT Components
  - Current above normal or grounded circuit
  - Current below normal or open circuit

Mechanical Failure

- Data erratic, intermittent or incorrect (also could be Communication failure)
- Mechanical system not responding or out of adjustment
- Abnormal rate of change

Fault Codes Types

ECM Logical Faults

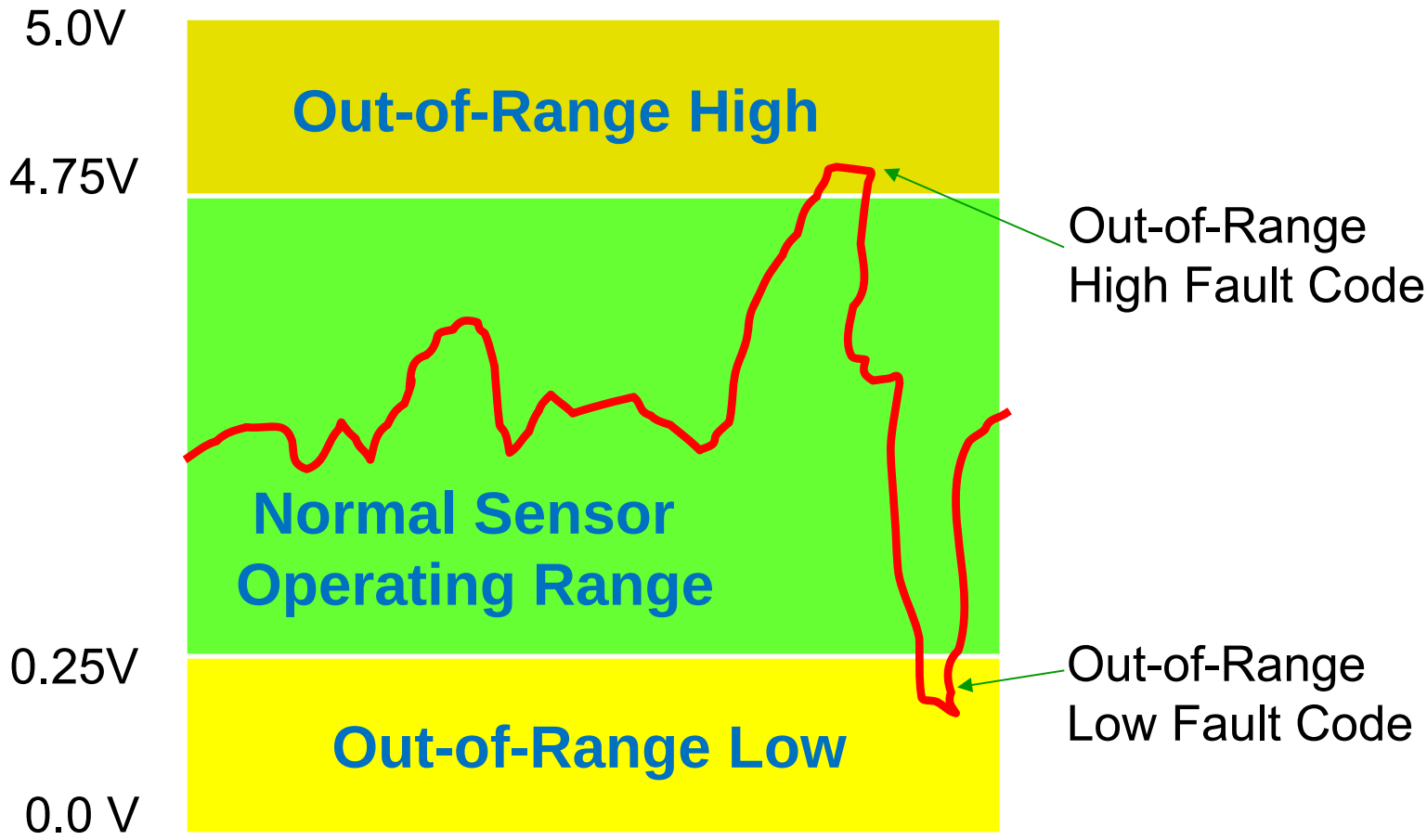
- Data not Rational
- Data erratic, intermittent or incorrect (also could be Mechanical failure)
- Data Valid But Above Normal Operating Range
  - Least Severe Level, Moderately Severe Level, Most Severe Level
- Data Valid But Below Normal Operating Range
  - Least Severe Level, Moderately Severe Level, Most Severe Level
- Condition Exists
- Out of Calibration

Communications Faults

- Received Network Data In Error
- Abnormal update rate
- Root Cause Not Known
- Bad intelligent device or component

ECM SENSOR READING

Sensor Voltage Range Operation



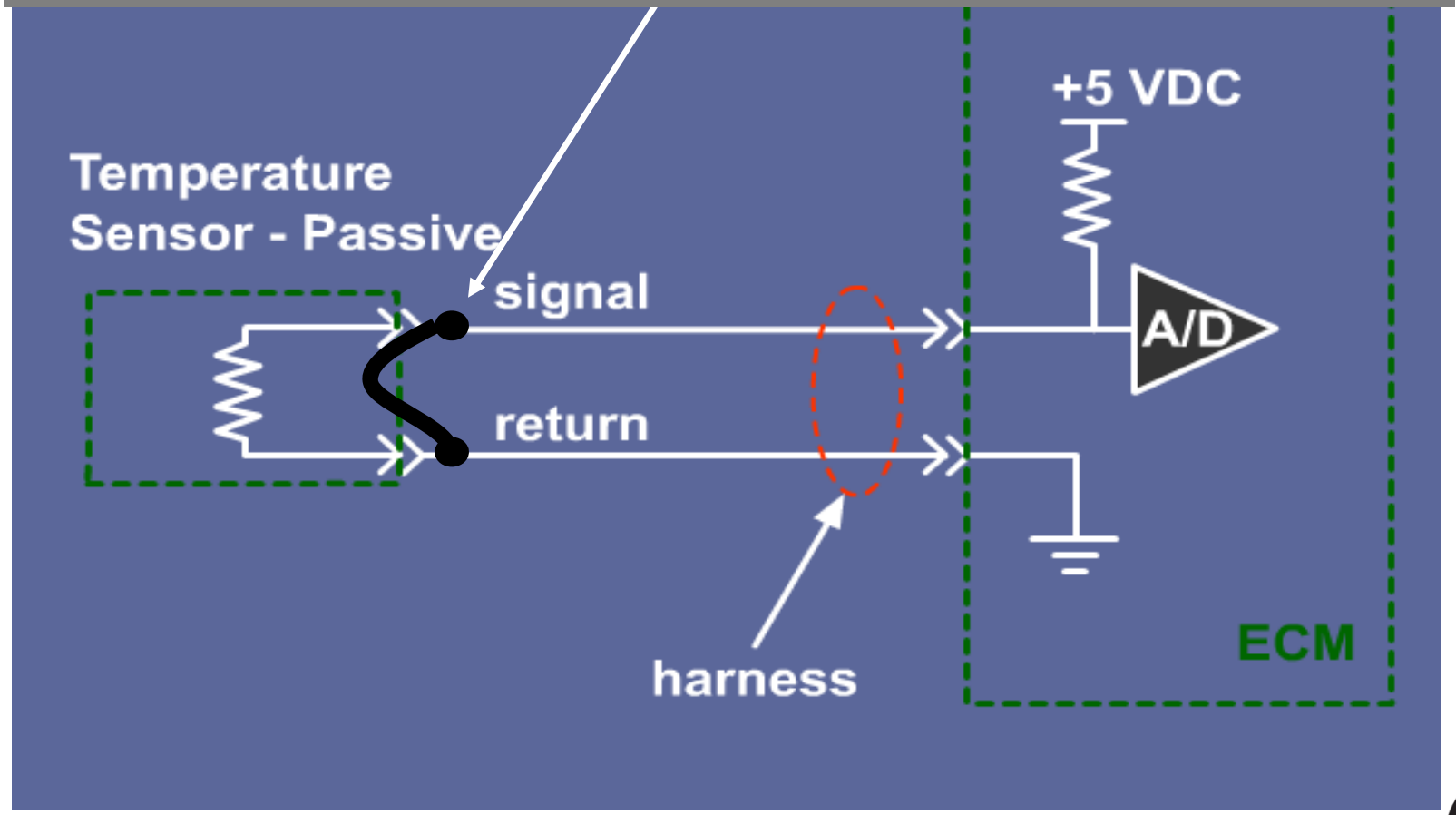
What is ‘Fault Code State Change’?

‘Fault Code State Change’ is the process of creating the ‘opposite’ fault code to troubleshoot sensors, harnesses, and ECM’s.

Understanding the ‘fault code state change’ logic can make troubleshooting as easy as disconnecting a sensor or unplugging the engine harness from the ECM.

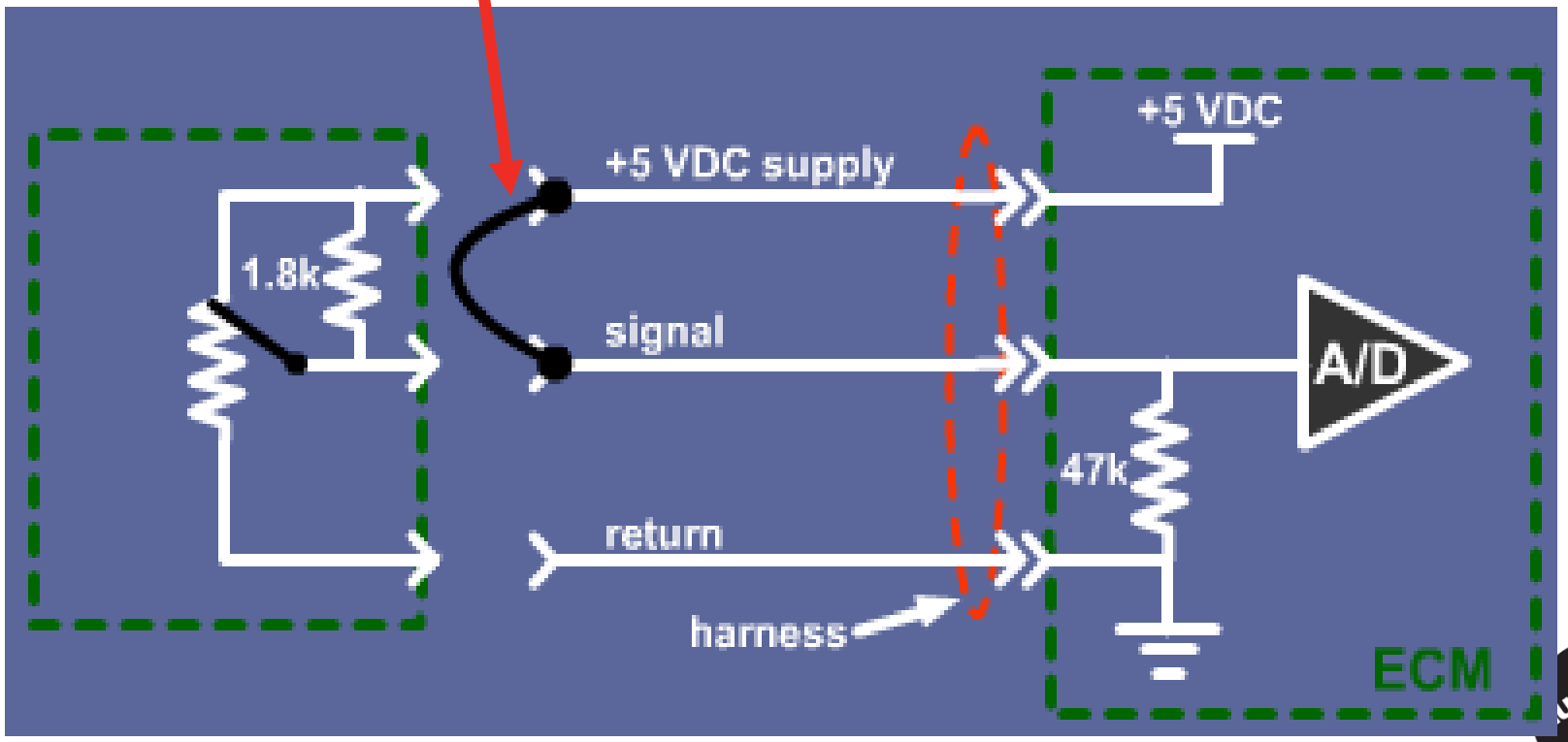
Temperature Sensor Diagnostics

Jumper the signal wire to the return wire to create an out-of-range low fault code on temperature sensors.



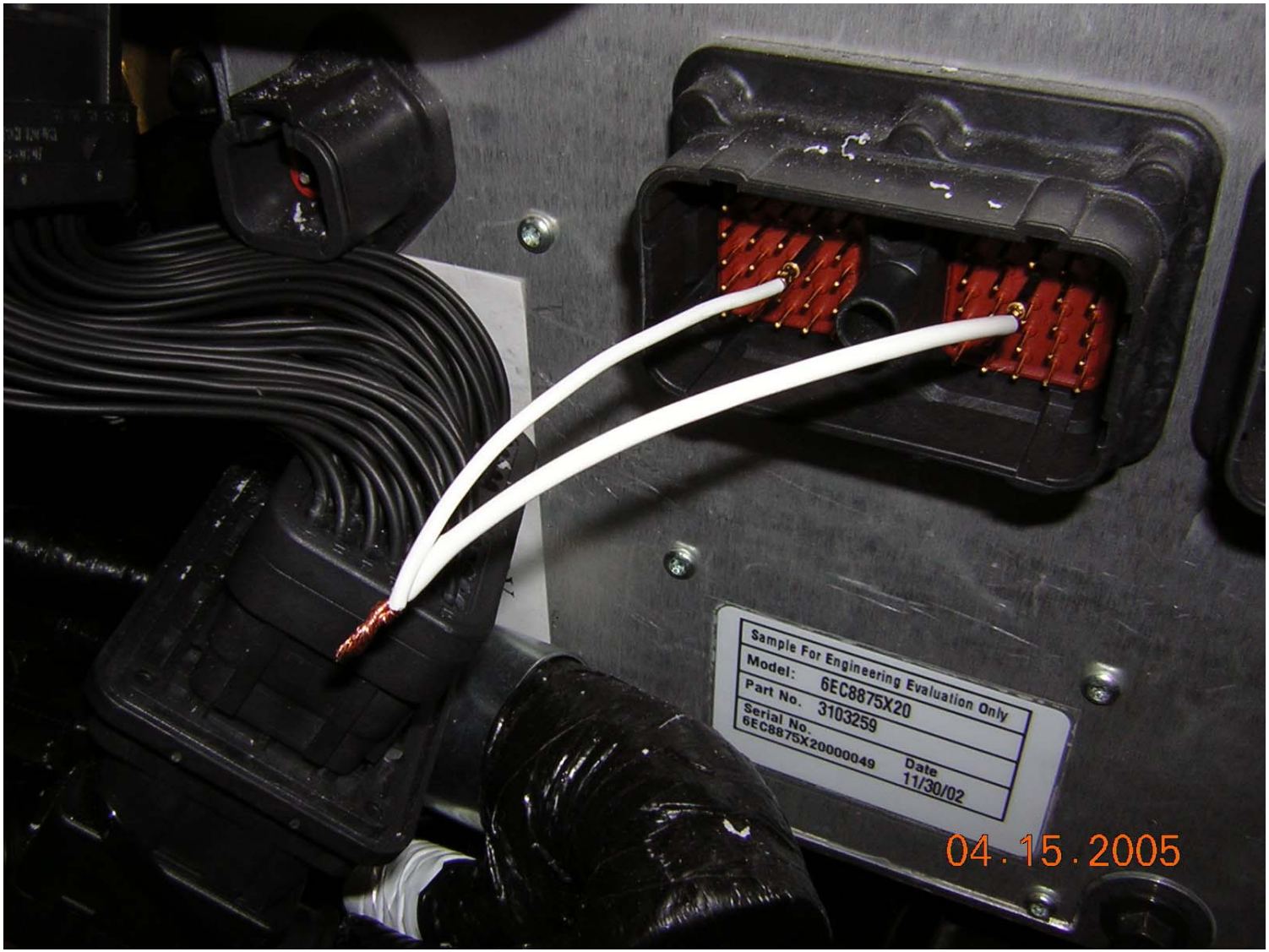
Pressure Sensor Diagnostics

Jumper the 5 volt supply to the signal wire to create an out-of-range high fault code on pressure sensors.



Using Test Leads to Change the Fault Code State

Using Test Leads to Change the Fault Code State

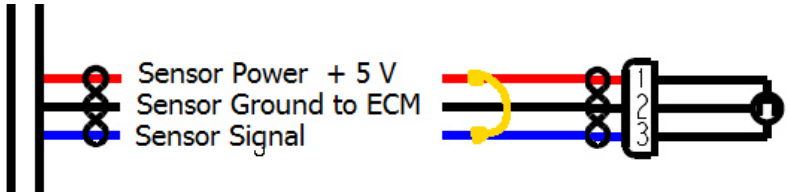


Electrical Failure

- INPUT Components
  - Voltage Above Normal, or Shorted to High Source
  - Voltage Below normal, or Shorted to Low Source
- OUTPUT Components
  - Current above normal or grounded circuit
  - Current below normal or open circuit

Electrical Failure:

Voltage Above Normal, or Shorted to High Source



Conditions for Running the Diagnostics

- **This diagnostic runs continuously when the keyswitch is in the ON position.**

Conditions for Setting the Fault Codes

- **Signal voltage is greater than 4.75-VDC for more than 5 seconds.**

Action Taken When the Fault Code is Active

- The ECM illuminates the amber CHECK ENGINE light and/or the malfunction indicator lamp (MIL) immediately when the diagnostic runs and fails.
- A default value of the sensor reading is used.
- Engine torque and speed could be reduced

Troubleshooting

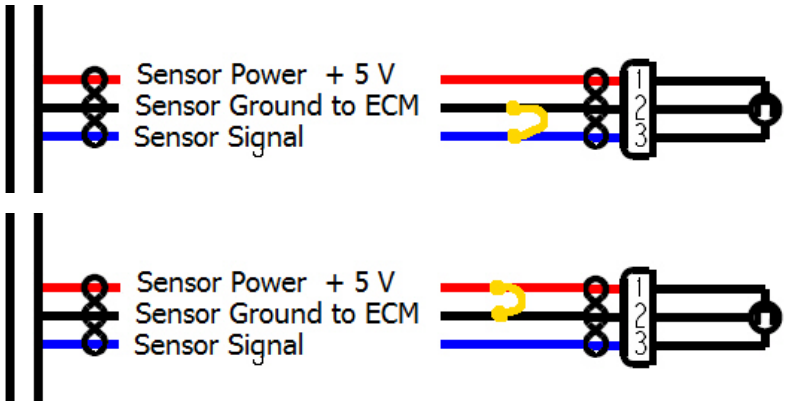
- QSOL procedure
- Fault code state change

Conditions for Clearing the Fault Code

- To validate the repair, **start the engine and let it idle for 1 minute.**
- The fault code status displayed by INSITE™ electronic service tool will change to INACTIVE immediately after the diagnostic runs and passes.
- The ECM will turn off the amber CHECK ENGINE lamp after the diagnostic runs and passes.
- **OBD engines**, the ECM will turn off the MIL *after three consecutive trips where the diagnostic runs and passes.*
- The “Reset All Faults” command in INSITE™ electronic service tool can be used to clear active and inactive faults, as well as extinguish the MIL for OBD engines.

Electrical Failure:

Voltage Below normal, or Shorted to Low Source



Conditions for Running the Diagnostics

- **This diagnostic runs continuously when the keyswitch is in the ON position.**

Conditions for Setting the Fault Codes

- **Signal voltage is Less than 0.25-VDC for more than 5 seconds.**

Action Taken When the Fault Code is Active

- The ECM illuminates the amber CHECK ENGINE light and/or the malfunction indicator lamp (MIL) immediately when the diagnostic runs and fails.
- A default value of the sensor reading is used.
- Engine torque and speed could be reduced

Troubleshooting

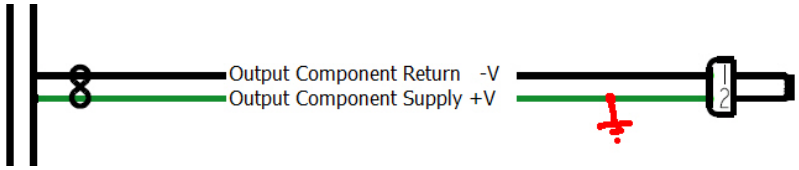
- QSOL procedure
- Fault code state change

Conditions for Clearing the Fault Code

- To validate the repair, **start the engine and let it idle for 1 minute.**
- The fault code status displayed by INSITE™ electronic service tool will change to INACTIVE immediately after the diagnostic runs and passes.
- The ECM will turn off the amber CHECK ENGINE lamp after the diagnostic runs and passes.
- **OBD engines**, the ECM will turn off the MIL *after three consecutive trips where the diagnostic runs and passes*.
- The “Reset All Faults” command in INSITE™ electronic service tool can be used to clear active and inactive faults, as well as extinguish the MIL for OBD engines.

Electrical Failure:

Current above normal or grounded circuit



Conditions for Running the Diagnostics

- **This diagnostic runs continuously when the engine is running.**

Conditions for Setting the Fault Codes

- **The electronic control module (ECM) detects a short circuit to ground in the EGR motor supply circuits.**

EGR Valve Control Circuit (Only on Midrange)

Action Taken When the Fault Code is Active

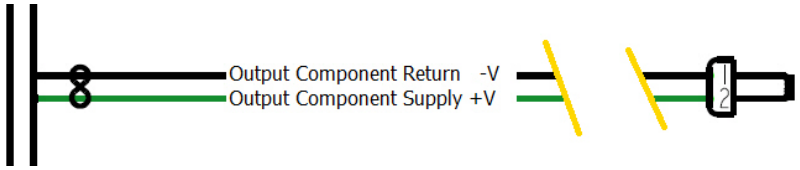
- The ECM illuminates the amber CHECK ENGINE lamp and/or the malfunction indicator lamp (MIL) immediately when the diagnostic runs and fails.
- Active and stationary regeneration of the diesel particulate filter will be disabled.
- The EGR valve will be closed.
- Engine torque will be reduced if the engine is operated for an extended period of time with this fault active.

Conditions for Clearing the Fault Code

- **The fault code will always be inactive at key ON. To validate the repair, start and idle the engine for 1 minute. If the fault code does not become active again, the repair has been validated.**
- The fault code status displayed by INSITE™ electronic service tool will change to INACTIVE immediately after the diagnostic runs and passes.
- The ECM will turn off the amber CHECK ENGINE lamp after the diagnostic runs and passes.
- For On-Board Diagnostics (OBD) engines, the ECM will turn off the malfunction indicator lamp (MIL) after three consecutive trips where the diagnostic runs and passes.
- The “Reset All Faults” command in INSITE™ electronic service tool can be used to clear active and inactive faults, as well as extinguish the MIL for OBD applications

Electrical Failure:

Current Below normal or Open circuit



Conditions for Running the Diagnostics

- **This diagnostic runs continuously when the engine is running.**

Conditions for Setting the Fault Codes

- **The electronic control module (ECM) detects an open circuits.**

Action Taken When the Fault Code is Active

- The electronic control module (ECM) illuminates the amber CHECK ENGINE lamp and/or the malfunction indicator lamp (MIL) immediately when the diagnostic runs and fails.
- Engine torque and speed could be reduced

Conditions for Clearing the Fault Code

- To validate the repair, perform a key cycle, and then start the engine and let it idle for 1 minute.
- The fault code status displayed by the INSITE™ electronic service tool will change to INACTIVE immediately after the diagnostic runs and passes.
- The ECM will turn off the amber CHECK ENGINE lamp after the diagnostic runs and passes.
- For OBD engines, the ECM will turn off the MIL after 3 consecutive trips where the diagnostic runs and passes.
- The “Reset All Faults” command in the INSITE™ electronic service tool can be used to clear active and inactive faults, as well as extinguish the MIL for OBD applications

Mechanical Failure:

Data erratic, intermittent or incorrect

Conditions for Running the Diagnostics

- **This diagnostic runs continuously when the keyswitch is in the ON position.**
- **This diagnostic runs when engine condition present.**

Conditions for Setting the Fault Codes

- **Signal is erratic, intermittent or incorrect**
  - Missing tooth on speed sensor, higher than achievable speed reading
  - Sensor reading does not match the engine operating conditions (high or low)
  - Sensor is reading an erratic value
  - Reading is **not** changing with the engine operating conditions

CM2350 Controls – Adaptive Trim Function for the Injectors

For most injectors previously used on Cummins XPI fuel systems injector trim codes (bar codes) were required.

With CM2350 control system there is no requirement to record and program injector trim code.

ECM has new function to monitor injector performance and compliance with EPA tail pipe exhaust emissions regulations.

How it works? During engine motoring events*,

- Engine motoring event - When you do a throttle snap in the shop or when you are at some road speed and quickly back off the throttle. It only adapts during a motoring event which is no commanded fuel but engine is above idle. Event of any rapid engine speed non-braking deceleration.
- ECM changes injector injection parameters,
- Records change of emissions and performance,
- ECM compares recorded data against pre-programmed parameters ,
- If there is discrepancy found, adjustments are made to injector timing and duration to comply with performance and emissions requirements.

Mechanical Failure:

Mechanical system not responding or out of adjustment

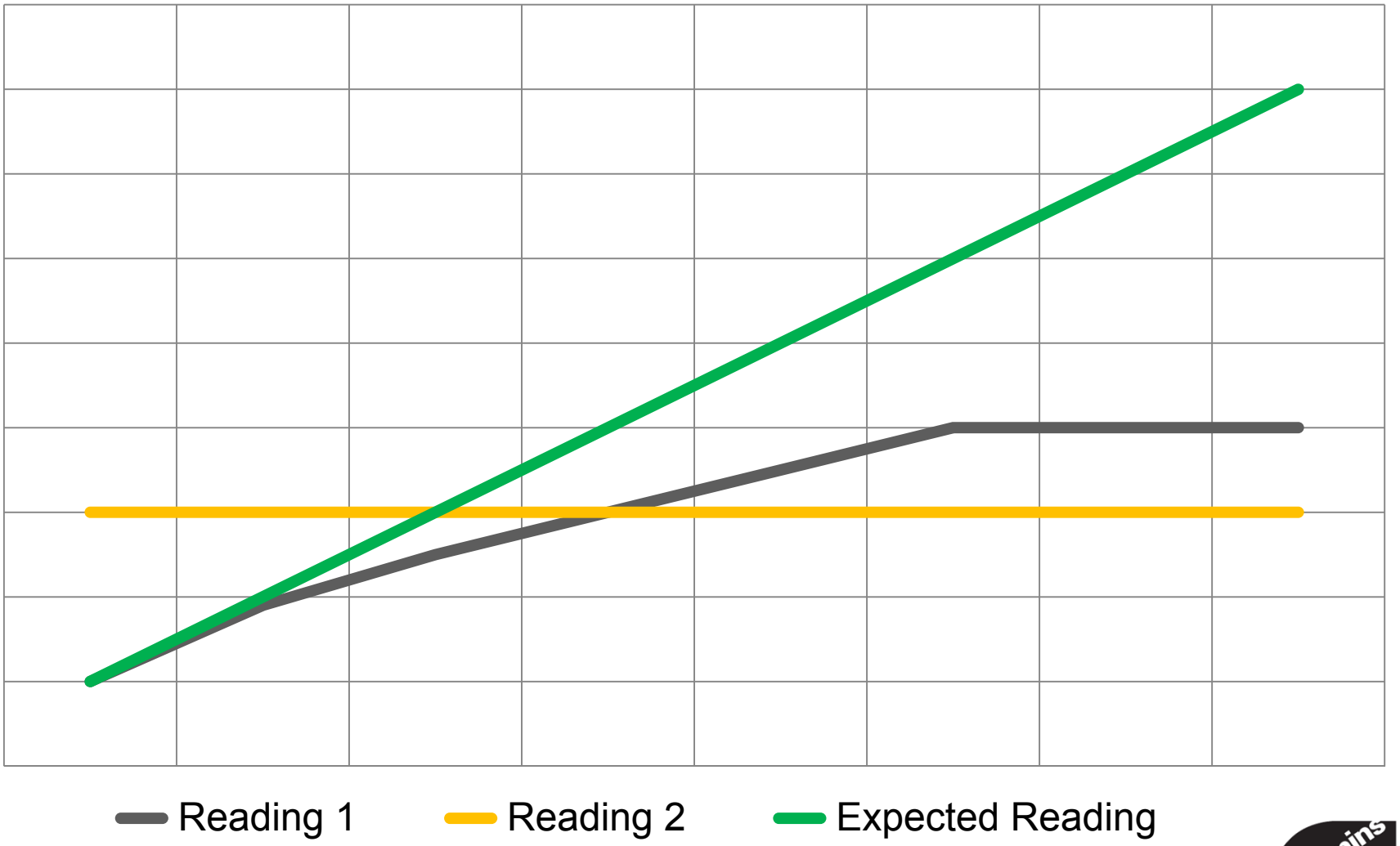
CODE	Sensor
177	Electronic Throttle Control Actuator
281	Engine Fuel Pump Pressurizing Assembly 1
731	Engine Speed / Position Camshaft and Crankshaft Misalignment
1139	Injector Solenoid Driver Cylinder 1
1141	Injector Solenoid Driver Cylinder 2
1142	Injector Solenoid Driver Cylinder 3
1143	Injector Solenoid Driver Cylinder 4
1144	Injector Solenoid Driver Cylinder 5
1145	Injector Solenoid Driver Cylinder 6
1963	Aftertreatment Fuel Shutoff Valve 1
2357	EGR Valve Control Circuit
2387	VGT Actuator Driver Circuit (Motor)
3225	Aftertreatment Purge Air Actuator
3242	Aftertreatment 1 Diesel Exhaust Fluid Tank Heater
3245	Aftertreatment 1 Diesel Particulate Filter System
3568	Aftertreatment Diesel Exhaust Fluid Dosing Valve
3569	Aftertreatment 1 Diesel Exhaust Fluid Dosing Unit Input Lines
3612	Aftertreatment 1 Diesel Exhaust Fluid Dosing Unit
3616	Engine VGT Nozzle Position
3713	Aftertreatment Diesel Exhaust Fluid Line Heater Relay
3727	High Pressure Common Rail Fuel Pressure Relief Valve
3751	Aftertreatment SCR Catalyst System
3876	Aftertreatment Diesel Exhaust Fluid Quality Sensor
4157	Aftertreatment Diesel Exhaust Fluid Return Valve

Fault Codes 1139-1145 are specific to adaptive trim function.

Mechanical Failure:
Abnormal rate of change

Code	Component	Caused
3145	Aftertreatment 1 SCR Intake Temperature Sensor	The ECM detects that the SCR catalyst intake temperature is not changing to match engine operating conditions.
3149	Aftertreatment 1 SCR Outlet Temperature Sensor	The ECM detects that the SCR catalyst outlet temperature is not changing to match engine operating conditions.
3361	Intake Manifold 1 Pressure	The ECM detects that the SCR catalyst outlet temperature is **not** changing to match engine operating conditions.
3389	Engine Exhaust Gas Recirculation (EGR) System	The measured EGR flow does not meet the commanded EGR flow for 30 seconds.
3492	Real Time Clock	The real time clock indicates a stuck engine off timer. The engine off timer is not counting correctly and does not match other timers in the ECM.
3583	Aftertreatment Outlet NOx Sensor Heater	The ECM detects that the NOx sensor heater is unable to maintain its normal operating temperature.
3649	Aftertreatment 1 Intake NOx Sensor Heater	The ECM detects that the NOx sensor heater is unable to maintain its normal operating temperature.
3725	Aftertreatment 1 Intake NOx Sensor	The aftertreatment intake NOx sensor reading is not valid.
3912	Aftertreatment 1 Outlet NH3 Gas Sensor Heater	The aftertreatment intake NH3 sensor reading is not valid.
3937	Aftertreatment 1 Intermediate NH3 Gas Sensor	The ECM detects that the Intermediate NH3 Gas reading is **not** changing to match engine operating conditions.

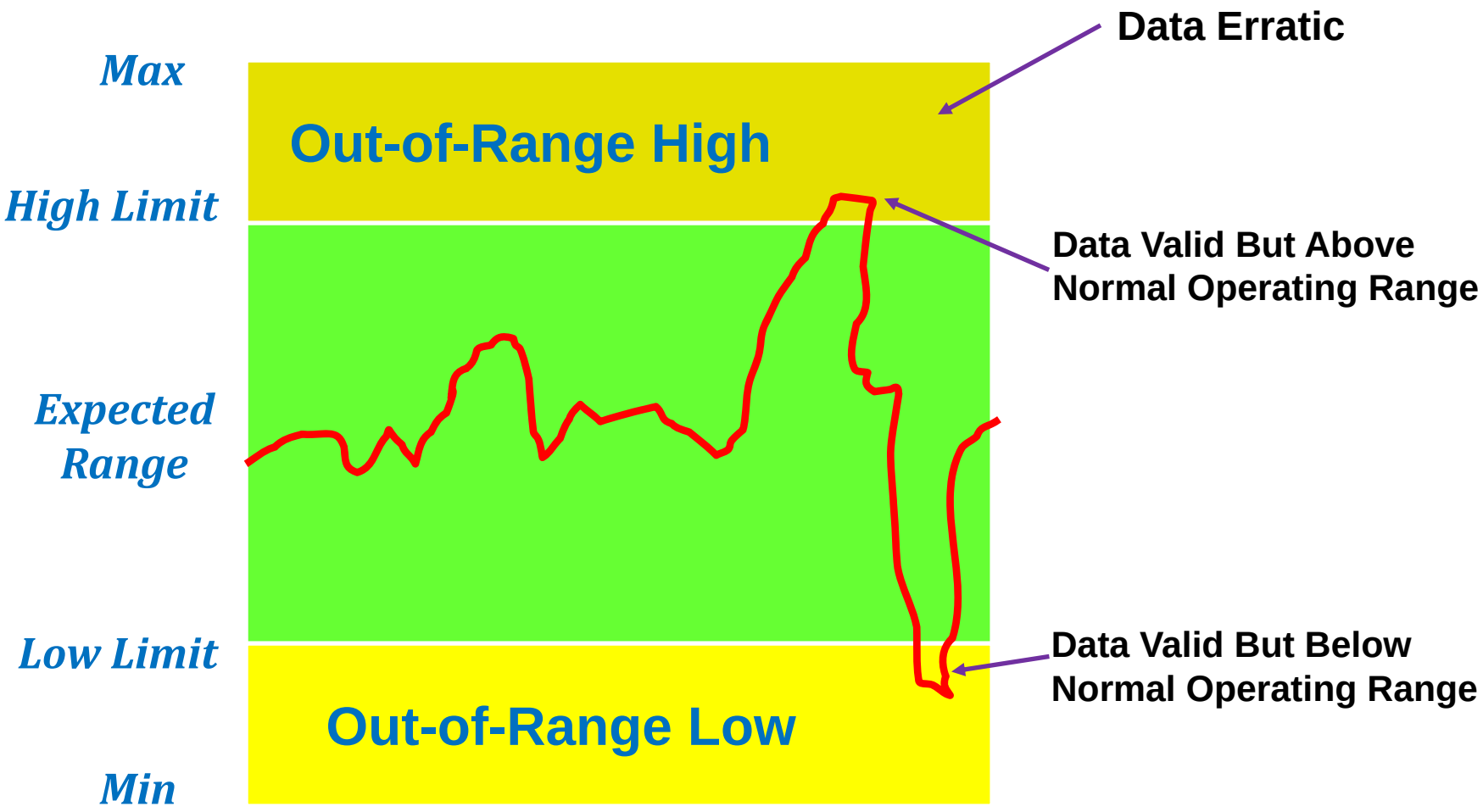
Abnormal rate of change



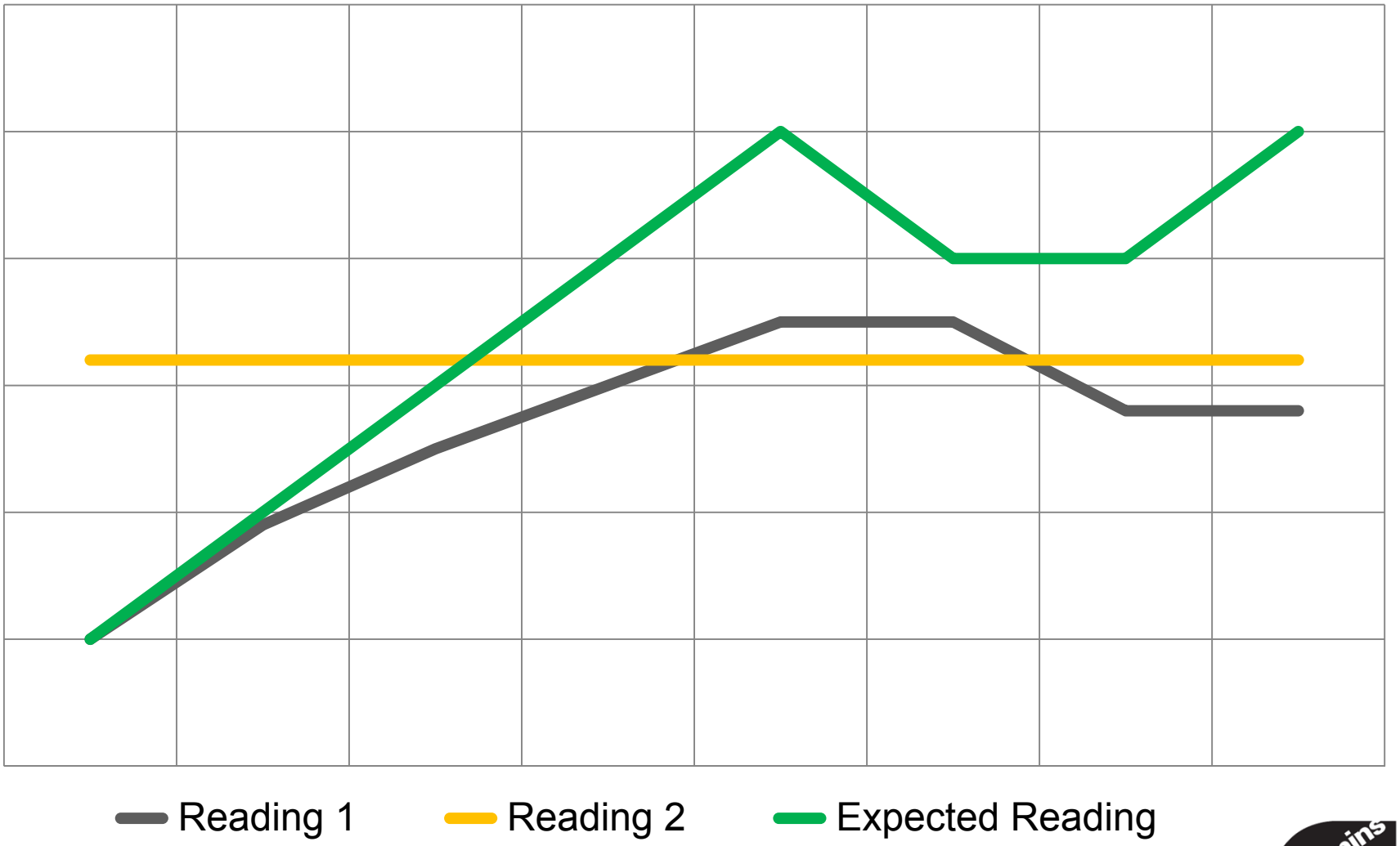
ECM Logical Faults

- Data not Rational
- Data erratic, intermittent or incorrect (also could be Mechanical failure)
- Data Valid But Above Normal Operating Range
  - Least Severe Level
  - Moderately Severe Level
  - Most Severe Level
- Data Valid But Below Normal Operating Range
  - Least Severe Level
  - Moderately Severe Level
  - Most Severe Level
- Condition Exists
- Out of Calibration

Sensor Reading Range



- Data not Rational
- Data erratic, intermittent or incorrect



ECM INPUTS

ECM Inputs – Sensors

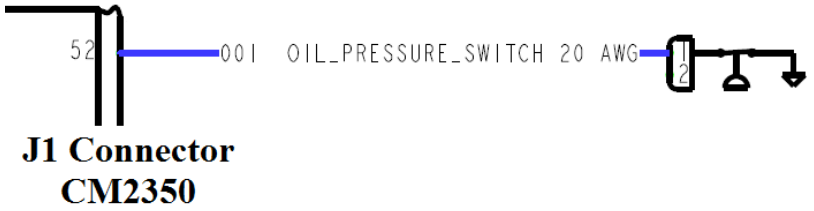
Engine Sensors

- Ambient Air Temperature Sensor (Required, OEM provided)
- Crankcase Ventilation System Pressure Sensor
- Engine Camshaft Speed / Position Sensor
- Engine Coolant Level Sensor 1
- Engine Coolant Level Sensor 2 (optional)
- Engine Coolant Temperature Sensor
- Engine Crankshaft Speed/Position Sensor
- Engine Exhaust Gas Recirculation Outlet Pressure Sensor
- Engine Fuel Temperature Sensor
- Engine Intake Throttle Actuator Position Sensor
- Engine Oil Rifle Pressure Sensor / Switch
- Exhaust Gas Pressure Sensor
- Exhaust Gas Recirculation Differential Pressure Sensor
- Exhaust Gas Recirculation Temperature Sensor
- Injector Metering Rail Pressure Sensor
- Intake Manifold Pressure Sensor
- Intake Manifold Temperature Sensor
- Turbocharger Compressor Intake Pressure Sensor
- Turbocharger Compressor Intake Temperature Sensor
- Turbocharger Speed Sensor
- Water in Fuel Indicator Sensor (Optional)
- Fuel Tank Level Sensor (OEM)

Aftertreatment Sensors

- Aftertreatment Diesel Exhaust Fluid Dosing Temperature Sensor
- Aftertreatment Diesel Exhaust Fluid Pressure Sensor
- Aftertreatment Diesel Exhaust Fluid Quality Sensor
- Aftertreatment Diesel Exhaust Fluid Tank Level Sensor
- Aftertreatment Diesel Exhaust Fluid Tank Temperature Sensor
- Aftertreatment Diesel Particulate Filter Differential Pressure Sensor
- Aftertreatment Diesel Particulate Filter Outlet Pressure Sensor
- Aftertreatment Diesel Oxidation Catalyst Intake Temperature Sensor
- Aftertreatment Diesel Particulate Filter Intake Temperature Sensor
- Aftertreatment Diesel Particulate Filter Outlet Temperature Sensor
- Aftertreatment Outlet NOx Sensor
- Aftertreatment Intake NOx Sensor
- Aftertreatment SCR Intermediate Temperature Sensor
- Aftertreatment SCR Intermediate NH3 Gas Sensor
- Aftertreatment SCR Outlet Temperature Sensor

Engine Oil Pressure Switch ISB6.7 Engine Only



Description

- An engine oil pressure switch is used by the electronic control module (ECM) to monitor the lubricating oil pressure .
- The oil pressure switch is normally closed when the engine is not running and open when the engine is running and oil pressure is present.

Fault Codes

- 415 - Engine Oil Rifle Pressure - Data Valid But Below Normal Operational Range
- 435 (Switch) - Engine Oil Rifle Pressure - Data Erratic, Intermittent, or Incorrect

415 - Engine Oil Rifle Pressure – Switch

Data Valid But Below Normal Operational Range - Most Severe Level

Conditions for Running the Diagnostics

- This diagnostic runs continuously when the engine is running.

Conditions for Setting the Fault Codes

- ***The ECM detects that the engine oil pressure is below minimum operating limits.***

Action Taken When the Fault Code is Active

- The ECM illuminates the red STOP ENGINE lamp immediately when the diagnostic runs and fails.
- A torque derate is issued by the ECM, limiting the power output of the engine .

Conditions for Clearing the Fault Code

- To validate the repair, start the engine and let it idle for 1 minute.
- The fault code status displayed by INSITE™ electronic service tool will change to INACTIVE immediately after the oil pressure reading is detected to be within the normal operating limits and the diagnostic runs and passes.
- The ECM will turn off the red STOP ENGINE lamp after the diagnostic runs and passes.
- The Reset All Faults command in INSITE™ electronic service tool can be used to clear active and inactive faults.

435 - Engine Oil Rifle Pressure – Switch
Data Erratic, Intermittent, or Incorrect

Conditions for Running the Diagnostics

- This diagnostic runs when the keyswitch is turned ON and before engine speed is detected. The diagnostic only runs once per trip.

Conditions for Setting the Fault Codes

- ***The ECM detects that the engine oil pressure switch is indicating that oil pressure is present (switch is open) at initial key ON for two consecutive key cycles, when the ECM expected to see no oil pressure (switch closed) at key ON.***

Action Taken When the Fault Code is Active

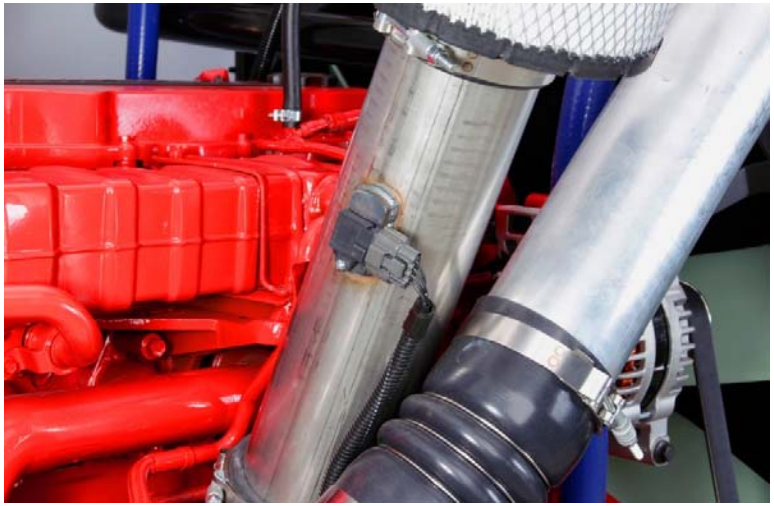
- The ECM illuminates the amber CHECK ENGINE lamp and/or Malfunction Indicator Lamp (MIL) immediately when the diagnostic runs and fails
- A default value for the engine oil pressure reading is used.

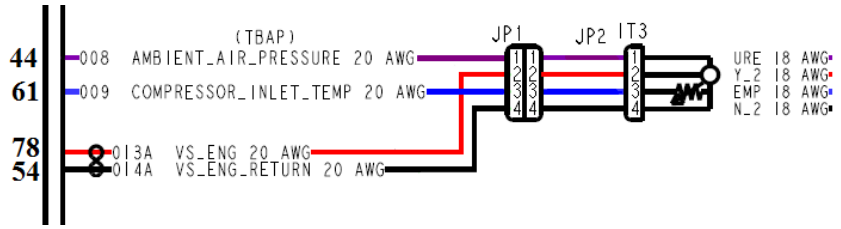
Conditions for Clearing the Fault Code

- To validate the repair, perform a key cycle. Turn the key to the ON position but do not start the engine .
- The fault code status displayed by INSITE™ electronic service tool will change to INACTIVE immediately after the diagnostic runs and passes.
- The ECM will turn off the amber CHECK ENGINE lamp after the diagnostic runs and passes.
- For On-Board Diagnostic (OBD) engines, the ECM will turn off the MIL after 3 (three) consecutive trips where the diagnostic runs and passes.

- The Reset All Faults command in INSITE™ electronic service tool can be used to clear active and inactive faults, as well as extinguish the MIL for OBD applications.

Turbocharger Compressor Intake Pressure Sensor





The turbocharger compressor intake temperature sensor is a variable resistor sensor and is used to measure the temperature of the air entering the compressor intake of the turbocharger . The electronic control module (ECM) supplies 5-VDC to the compressor intake temperature signal circuit. This sensor signal voltage changes, based on the pressure in the intake manifold.

Component Location

- Most engines use a combination ambient air pressure /temperature sensor located in the OEM intake air plumbing.

Fault Codes:

- 122 - Voltage above normal, or shorted to high source
- 123 - Voltage below normal, or shorted to low source
- 124 - Data Valid But Above Normal Operating Range - Moderately Severe Level – **High Pressure**
- 125 - Data Valid But Below Normal Operating Range - Moderately Severe Level – **Low Pressure**

124 - Intake Manifold 1 Pressure – Data Valid But ***ABOVE*** Normal Operating Range - Moderately Severe Level

Conditions for Running the Diagnostics

- This diagnostic runs continuously when the engine is running.

Conditions for Setting the Fault Codes

- The ECM detects that the VGT actuator is slow to meet commanded position.
- *Intake manifold pressure is above the maximum operating limit.*

Action Taken When the Fault Code is Active

- The ECM illuminates the amber CHECK ENGINE lamp immediately when the diagnostic runs and fails.

Conditions for Clearing the Fault Code

- To validate the repair, start the engine and let it idle for 5 minutes.
- For On-Board Diagnostics (OBD) engines, the ECM will turn off the MIL after three consecutive trips where the diagnostic runs and passes.

125 - Intake Manifold 1 Pressure – Data Valid But ***BELOW*** Normal Operating Range - Moderately Severe Level

Conditions for Running the Diagnostics

- This diagnostic runs continuously when the engine is running.

Conditions for Setting the Fault Codes

- The ECM detects that the intake manifold pressure signal reading is below the expected level for the present engine operating conditions. *Intake manifold pressure is below the minimum operating limit.*

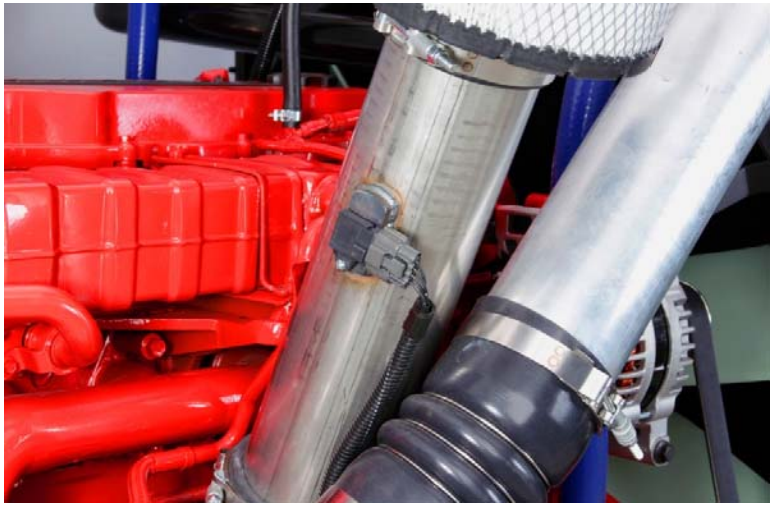
Action Taken When the Fault Code is Active

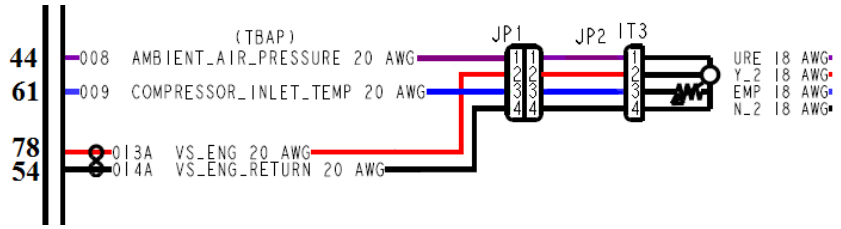
- The ECM illuminates the amber CHECK ENGINE lamp and/or the malfunction indicator lamp (MIL) immediately when the diagnostic runs and fails.

Conditions for Clearing the Fault Code

- The fault code status displayed by INSITE™ electronic service tool will change to INACTIVE after the engine is able to achieve the desired oxygen level necessary for complete combustion and the diagnostic runs and passes.
- *For on-board diagnostics (OBD) engines, the ECM will turn off the MIL after three consecutive trips where the diagnostic runs and passes.*

Turbocharger Compressor Intake Temperature Sensor





The intake manifold 1 temperature sensor is a variable resistor sensor and is used to measure the temperature of the air entering the intake manifold of the engine. The engine intake manifold temperature value is used by the electronic control module (ECM) for the engine protection system and engine emissions control.

The ECM supplies 5 volts to the intake manifold temperature signal circuit, and monitors the change in voltage caused by changes in the resistance of the sensor to determine the intake manifold temperature.

- Low Temperature – High Resistance – High Voltage at ECM
- High Temperature – Low Resistance – Low Voltage at ECM

Component Location

- The intake manifold air temperature sensor is located in the air intake manifold.

Fault Codes

- 153 - Voltage above normal, or shorted to high source
- 154 - Voltage below normal, or shorted to low source
- 155 - Data valid but above normal operational range - Most Severe Level - **High Temperature**

155 - Intake Manifold 1 Temperature - Data Valid But Above Normal Operational Range - Most Severe Level

Conditions for Running the Diagnostics

- This diagnostic runs *continuously when the keyswitch is in the ON position.*

Conditions for Setting the Fault Codes

- Intake manifold air temperature reading is *greater than 132°C [270°F] for 5 sec.*

Action Taken When the Fault Code is Active

- The ECM illuminates the red STOP ENGINE light immediately when the diagnostic runs and fails.
- The torque output of the engine will be reduced.
- Maximum engine operating speed will be decreased.
- The engine will be shut off if the Engine Protection Shutdown feature is enabled.

Conditions for Clearing the Fault Code

- To validate the repair, *start the engine and let it idle for 1 minute.*
- The fault code status displayed by the INSITE™ electronic service tool will change to INACTIVE immediately after the diagnostic runs and passes.
- The ECM will turn off the red STOP ENGINE lamp after the diagnostic runs and passes.

ECM Inputs - Sensors - OEM Provided

Accelerator Position Sensor

- Dual Analog
- PWM

Ambient Air Temperature Sensor

Engine Coolant Level Sensor 1 & 2

Fan Speed Sensor

Magnetic Pickup VSS

Remote Accelerator Position Sensor

Water in Fuel Sensor

DEF Tank Temperature Sensor

DEF Tank Level Sensor

Fuel Tank Level Sensor

ECM Inputs - Switches - OEM Provided

- Accelerator Interlock Switch/ Torque Limit Switch
- Air Conditioner Pressure Switch
- Air Shutoff Valve Manual Switch
- Air Shutoff Valve Test Switch
- CC/PTO On/Off Switch
- CC/PTO Set/Resume Switch
- Clutch Switch
- Diagnostics On/Off Switch/ Diesel Particulate Filter Regeneration Force Switch
- Regeneration Inhibit Switch
- Engine Brake On/Off Switch (VGT Brake)
- 3-Position Engine Brake Level Switch (Compression Brake)
- Engine Protection
- Shutdown Override Switch
- Multiplexed Accelerator Error Limp Home Switch
- Fan Control Switch
- Governor Type Switch/ Switched Max Engine Speed/Switched RSG
- OEM Switched Engine Protection Shutdown Switch
- Parking Brake Switch
- PTO Additional Switch
- Rear Axle Ratio Switch
- Remote Accelerator On/Off Switch
- Remote PTO On/Off Switch
- Service Brake Pedal Position Switch
- Service Brake Validation Switch

ECM Outputs - Lamps and Gauges- OEM Provided

Amber Warning Lamp

Air Shutoff Valve Lamp

Diesel Exhaust Fluid Lamp

Diesel Exhaust Fluid Level Gauge

Diesel Particulate Filter Lamp

High Exhaust System Temperature (HEST) Lamp

Malfunction Indicator Lamp (MIL)

Stop Lamp

Wait To Start (WTS) Lamp

RELAYS / SOLENOIDS

Standard Relay

The relays described in this section will function for many of the OEM supplied relays used with the CM2350 subsystem. Where a different relay is required (e.g. Intake Air Heaters), an example relay is supplied in the specific section.

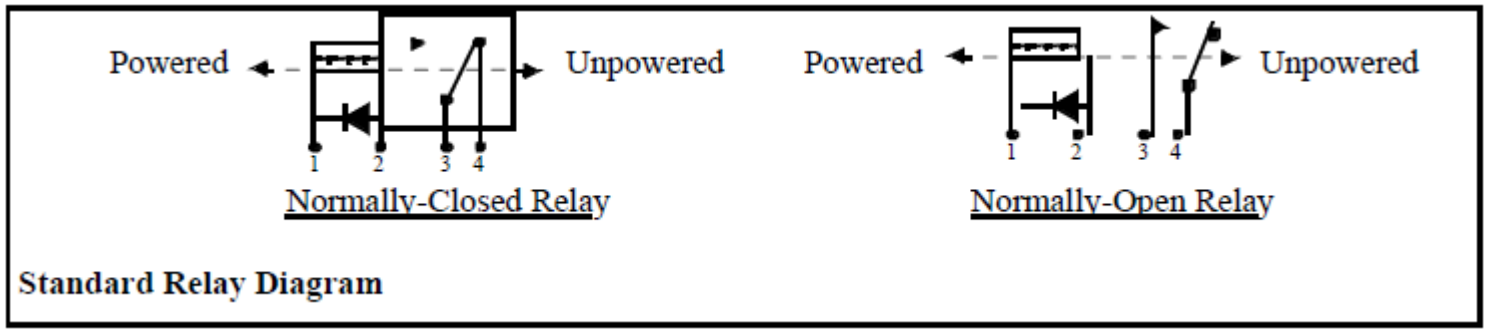
Operation

- Relays can operate in a Normally-Open or Normally-Closed fashion. The Normally-Open or Normally-Closed refers to the condition of the relay terminals when power is not being supplied to the relay coil.

Hardware

- Any relay using the Standard Relay specification MUST meet the specifications in the table below. This description uses terminal numbers on the relays for reference only; a particular relay may use a different numbering scheme. Cummins recommends using relays that contain an integral suppression diode.

Standard Relay



Standard Relay Diagram

Item	Requirement	
	Normally Closed Relays	**Normally Open Relays**
Terminal Action	Normally Closed	Normally Open
Minimum Number of Terminals	Four: Terminals 1, 2, 3 and 4 (ref only)	Four: Terminals 1, 2, 3 and 4 (ref only)
Minimum Number of States	Two: Powered or Unpowered	Two: Powered or Unpowered
- Powered	Terminals 3-4 Open	Terminals 3-4 Closed
- Unpowered	Terminals 3-4 Closed	Terminals 3-4 Open
OEM Coil Supply Voltage	Battery Voltage	Battery Voltage
Maximum Coil Current	2 A	2 A
Maximum Coil Inductance	12 V Relay – 80 mJ Load Limit (0.5 * Inductance * Current^2) 24 V Relay – 260 mJ Load Limit	

ECM Outputs - Relays/Solenoids - OEM Provided

- Air Shut Off Valve / Idle Shutdown Relay
- Brake Lamp Relay
- Air Heater Relay (MR Only)
- Fan Clutch Relay/Solenoid
- Fuel Heater Relay
- Starter Lockout Relay
- DEF Line Heater Relay
- DEF Line 4 (Dosing Unit) Heater Relay
- DEF Coolant Flow Valve Solenoid

Air Shut Off Valve MR / HD

Overview

- The Air Shut Off Valve provides power to control the air flow to the engine ASO device (Pneumatic System), when the ECM detects an engine over speed due to combustible gas in the environment in which the engine is operating.

Operation

- When the ASO solenoid valve is energized, the air flow coming from the reservoir tank is directed to the ASO valve and triggers the ASO valve (Pneumatic System). When the solenoid valve is de-energized, the air is released from the ASO valve.

Hardware

- Cummins recommends a 3-way solenoid valve to be used for the ASO valve control.
- Note: ASO solenoid drive signal is mutually exclusive with the Idle Shutdown Relay signal.

Idle Shutdown Relay

Overview

- The Idle Shutdown relay disconnects power from selected highcurrent vehicle systems when the Idle Shutdown feature shuts down the engine. The Idle Shutdown feature turns off the engine and energizes the Idle Shutdown Relay after a programmable time period of engine idling without interruption has been exceeded.

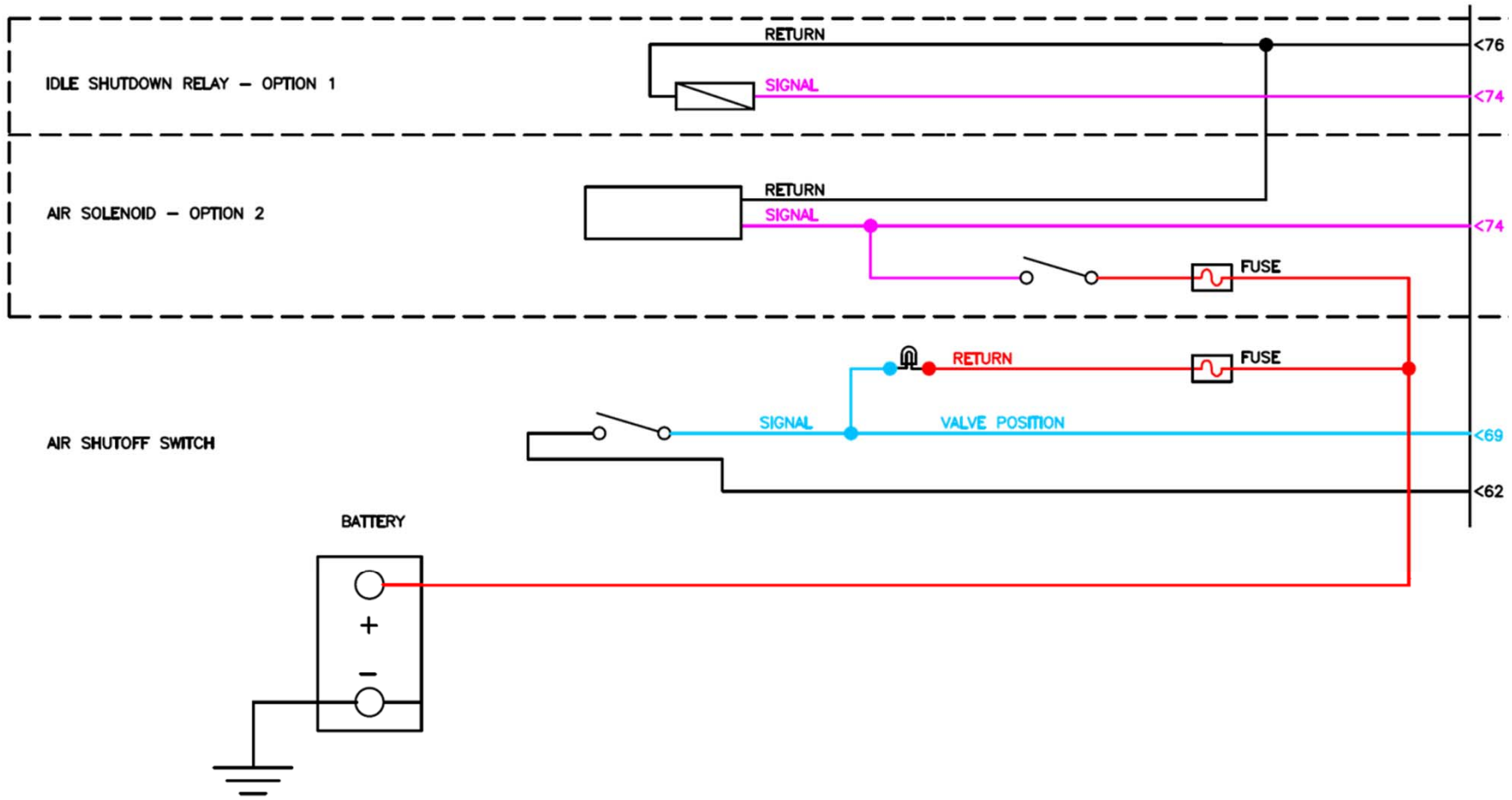
Operation

- When the relay is energized; the terminals OPEN and disconnect power from high current devices. When the relay is not energized, the terminals are CLOSED, allowing power to high current devices.

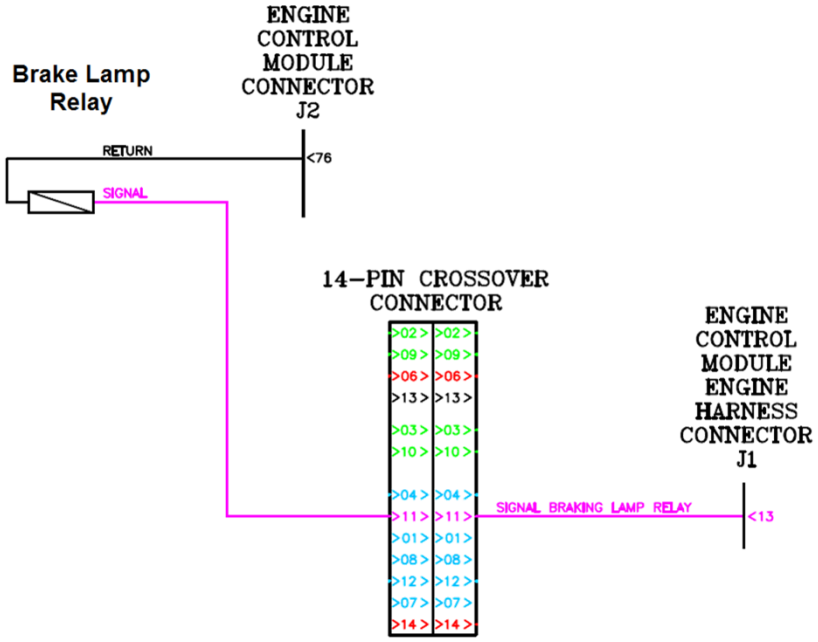
Hardware

- The Idle Shutdown Relay MUST meet the specifications for a Normally-Closed Standard Relay as described in the Standard Relay section below.
- Note: Idle Shutdown Relay signal is mutually exclusive with the ASO solenoid drive signal.

Air Shut Off Valve



Brake Lamp Relay



Overview

- The Brake Lamp relay provides power to energize the vehicle brake lamps when the Engine Brakes are ON.

Operation

- When the relay is energized, the terminals are CLOSED, allowing power to the vehicle brake lamps. When the relay is not energized, the terminals are OPEN and disconnect power from the brake lamps.

Hardware

- The Brake Lamp Relay MUST meet the specifications for a Normally-Open Standard Relay as described in the Standard Relay section below.

Intake Air Heater Relay (ISB6.7 and ISL9 Only)

The ECM uses the Intake Air Heater Relay to energize the Intake Air Heater during cold ambient temperatures. OEM MUST have a relay installed for all 2013 ISB6.7 and ISL9 engines.

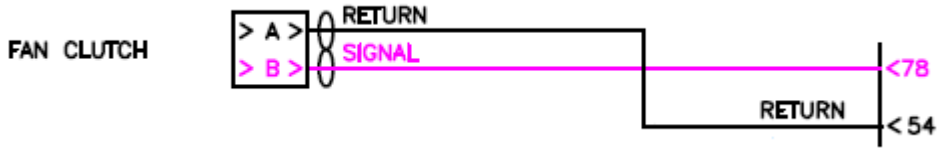
Operation

- During cold ambient temperatures the ECM uses the relay to energize the intake air heater prior to and following the starting of the engine. The ECM will de-energize the relays during engine cranking.

Hardware

- Any Intake Air Heater Relay MUST match the specifications from the table below. The relay contacts SHOULD support the nominal continuous and in rush current draws requirements. The wiring SHOULD also be protected with an adequately sized fuse or circuit breaker that can accommodate the current draw characteristics of the Intake Air Heater Element.

Fan Clutch Relay/Solenoid



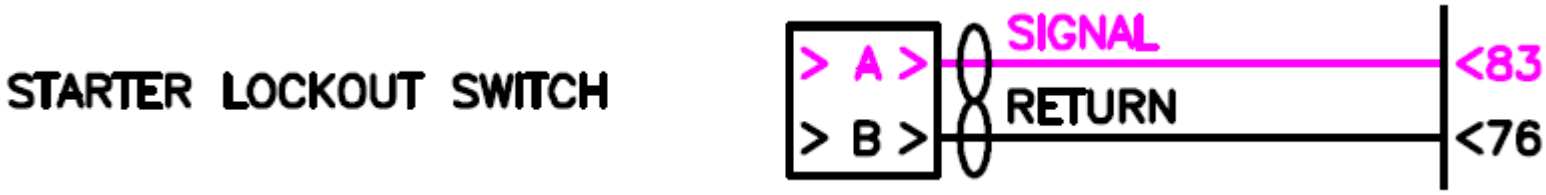
Overview

- The Fan Clutch Relay/Solenoid controls engagement of the fan drive. There are various types of fan drive control components some operate in an On/Off fashion typically by controlling electrical power (Relay) or compressed air (Solenoid) to the fan clutch.

Operation

- The Fan Clutch Relay/Solenoid may operate in a Normally Open or Normally Closed condition. Without full knowledge of the vehicle setup, it cannot be specified whether this Relay/Solenoid should be Normally Open or Normally Closed.
- Recommended practice would be for the fan to be fully engaged for an open circuit condition. The ECM signal to turn the Fan ON may be programmed as a high or low voltage signal

Starter Lockout Relay



The starter lockout relay is controlled by the engine control module (ECM) through the starter lockout relay signal circuit. The relay prevents the starter from being engaged when the engine is running. The relay return circuit is dependent on OEM wiring. It can be wired back to the ECM on some vehicles or wired to chassis or block ground on others. Consult the OEM wiring diagram for return circuit details. The starter lockout relay circuit utilizes a pulse width modulated (PWM) signal. A PWM signal is a pulsed voltage signal between 0-VDC and system voltage. The frequency of the pulsed voltage signal is dependent on the application requirement.

DEF Line Heater Relay

Overview

- The DEF Line Heater relay is controlled by the Engine Control Module (ECM). OEM MUST power all three DEF line (Pressure, Suction and Throttle lines) heating equipment to ensure vehicle acceptance for all seasons.

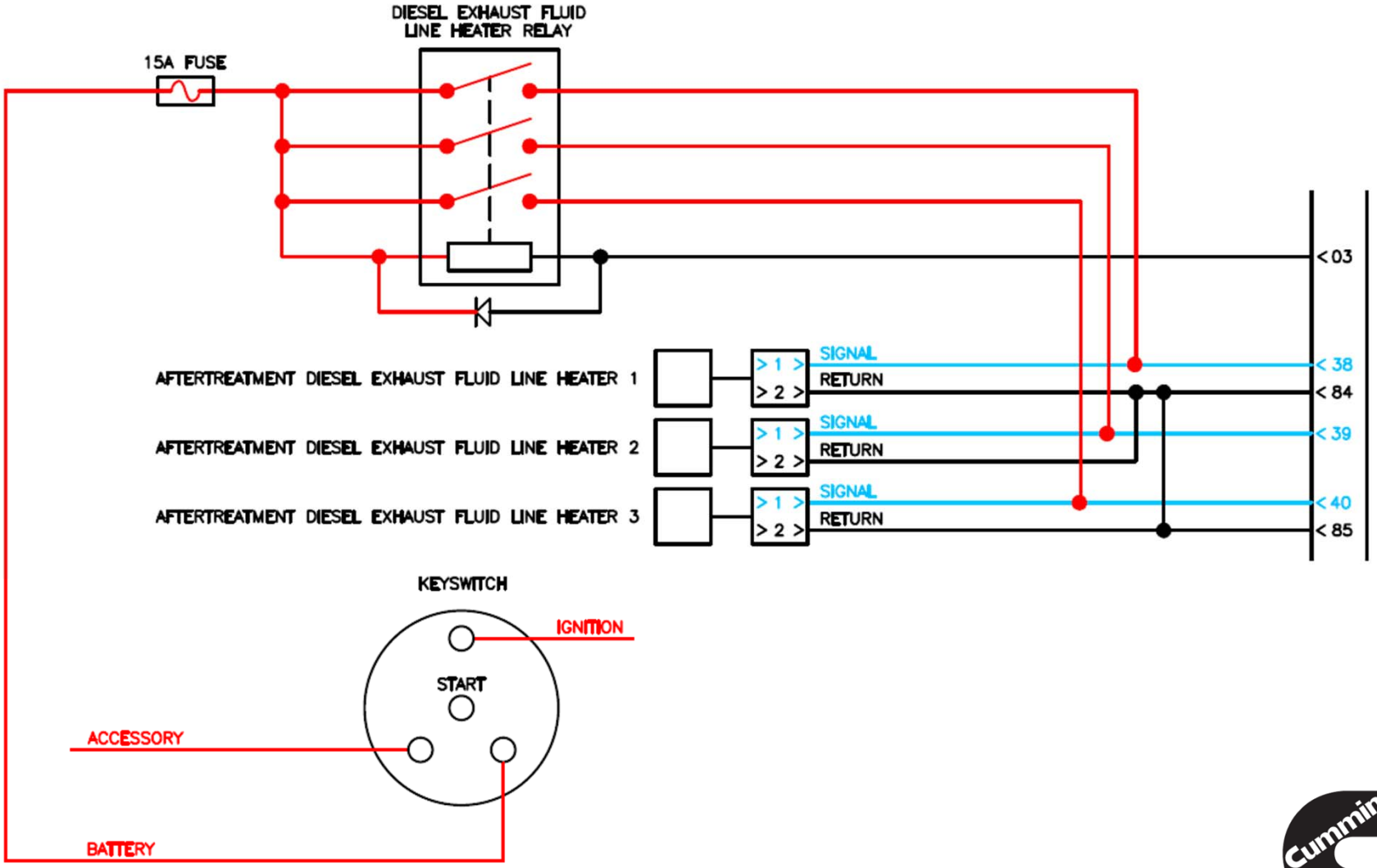
Operation

- When the DEF Line Heater relay is energized by the ECM, the DEF line heaters are powered up by the battery voltage. When the relay is de-energized, the power to the line heaters is cut off.

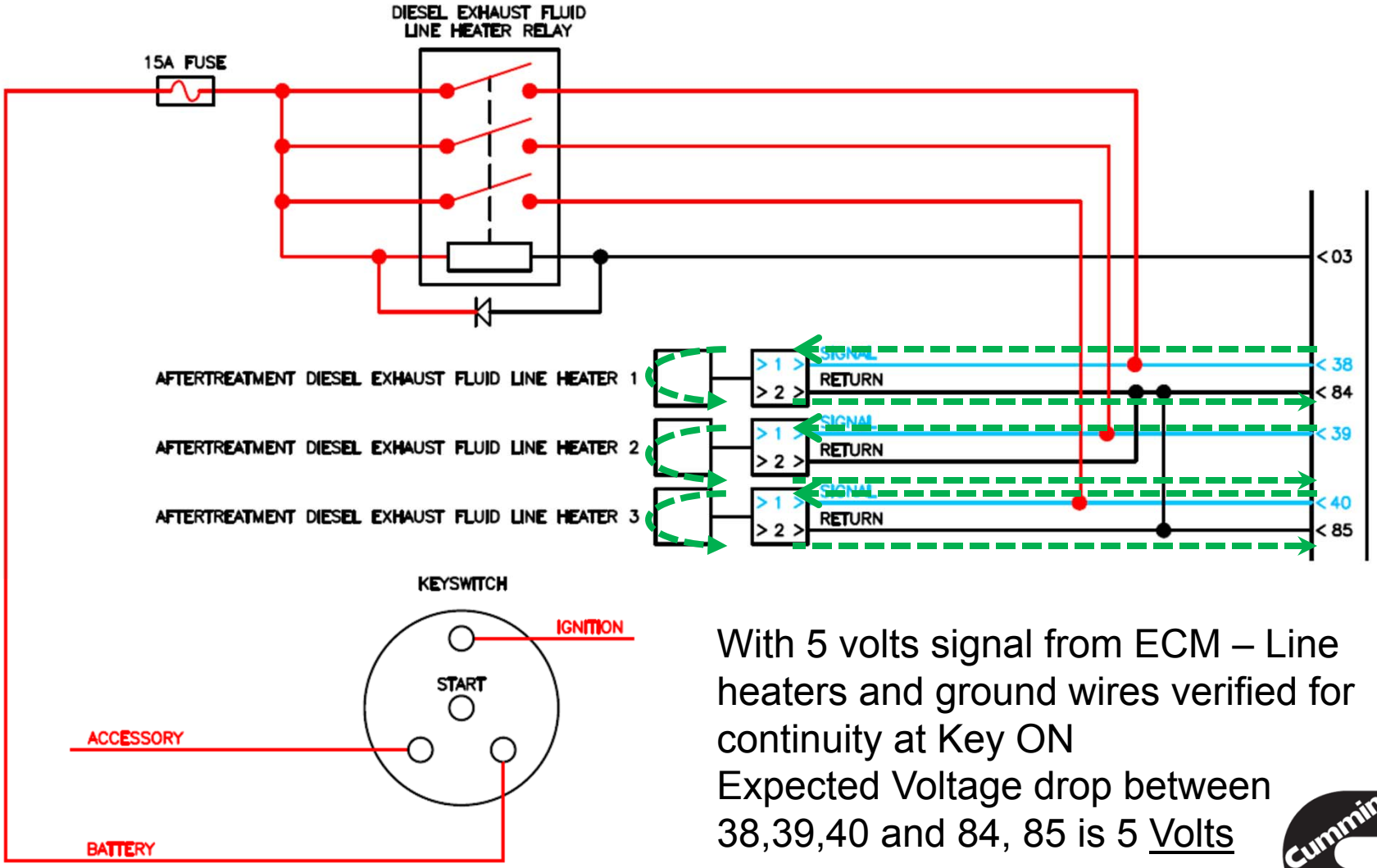
Hardware

- The line heaters are controlled by a single high side relay (single relay with diode line isolation, single 3-pole relay, or three separate relays if desired), all lines ON or all lines OFF. The DEF line heater relay MUST meet an expected life of 2 million operation cycles at rated current.
- Each line heater circuit MUST be separated when the relay is open to allow individual line diagnostics to complete. Line heater return MUST be through the ECM also to support line heater diagnostics.

DEF Line Heater Relay



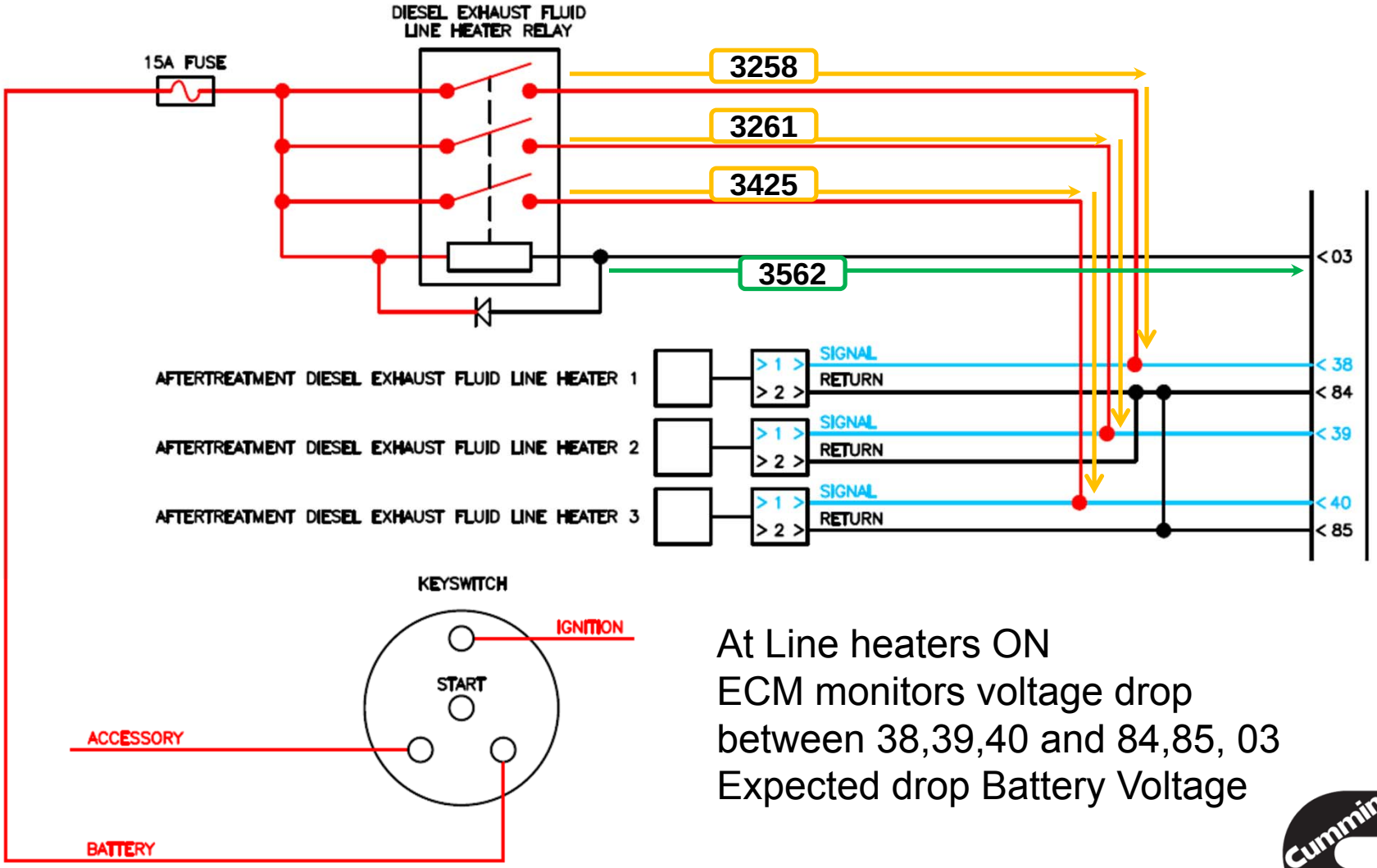
DEF Line Heater Relay – at key ON



With 5 volts signal from ECM – Line heaters and ground wires verified for continuity at Key ON

Expected Voltage drop between 38,39,40 and 84, 85 is 5 Volts

DEF Line Heater Relay – Relay energized



At Line heaters ON
ECM monitors voltage drop between 38,39,40 and 84,85, 03
Expected drop Battery Voltage

DEF Supply Module Heater Relay

Overview

- The DEF Supply Module Heater relay is controlled by the Engine Control Module (ECM). OEM MUST power the DEF Supply Module Heater equipment to ensure vehicle acceptance for all seasons.

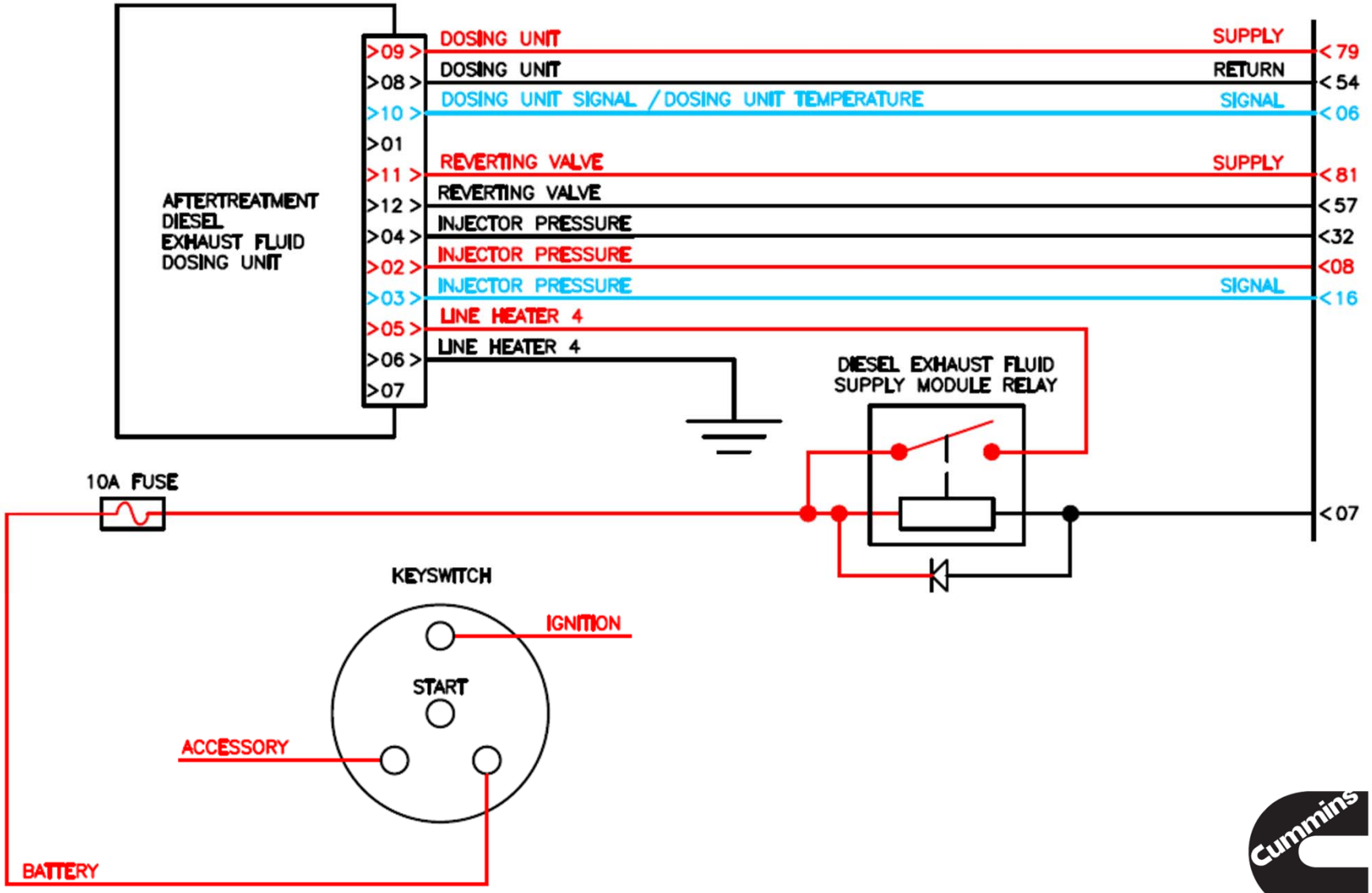
Operation

- When the DEF Supply Module Heater relay is energized by the ECM, the DEF Supply Module heater is powered up by the battery voltage. When the relay is de-energized, the power to the heater is cut off.

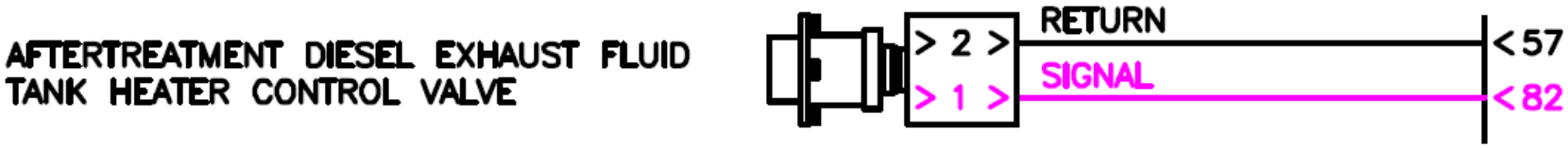
Hardware

- The DEF Supply Module Heater relay MUST be a normally open standard relay.

DEF Supply Module Heater Relay



DEF Coolant Flow Valve



Overview

- The DEF Coolant Flow Valve is controlled by the Engine Control Module (ECM). OEM MUST supply and connect the DEF Coolant Flow Valve and plumbing equipment to ensure vehicle acceptance for all seasons.

Operation

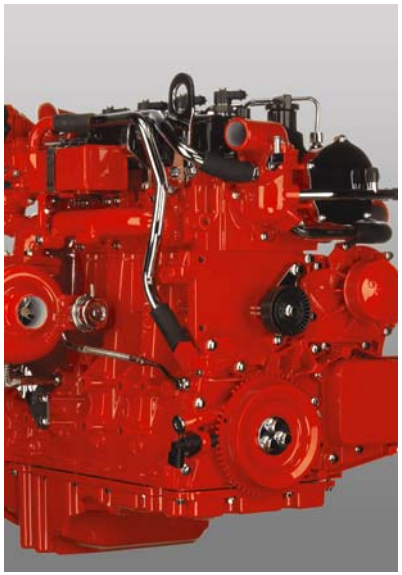
- When the DEF Coolant Flow Valve is energized by the ECM, coolant is allowed to flow to the DEF Tank for proper DEF tank heating. When the valve is de-energized, the coolant flow is cut off. Valve Action - Is Normally Closed.

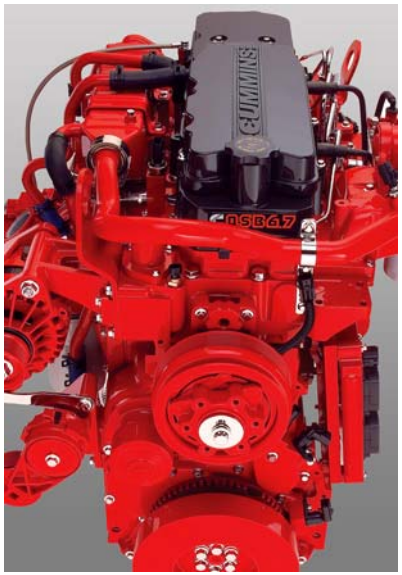
Hardware

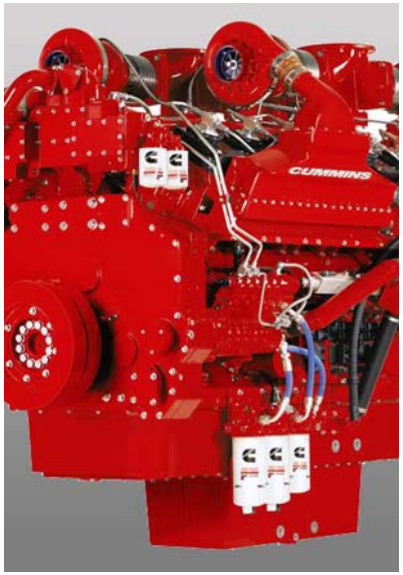
- It is recommended that the valve sourced incorporates coil suppression.

CM2350 Controls

INTERNAL FUNCTION AND ECM SERVICE TESTS







INSITE, ECM Diagnostic Tests

1	Aftertreatment Diesel Exhaust Fluid System Leak Test	Aftertreatment
2	Aftertreatment Diesel Particulate Filter Regeneration	Aftertreatment
3	Cylinder Cutout	Fuel system
4	Cylinder Performance Test	Fuel system
5	Diesel Exhaust Fluid Doser Pump Override Test	Aftertreatment
6	Diesel Exhaust Fluid Doser System Heater Test	Aftertreatment
7	Engine State Monitor	Controls
8	Fan Override Test	Controls
9	Fast Idle Warm-Up Test	Controls
10	Fuel System Leakage Test	Fuel system
11	Fuel Lift Pump Override Test (ISL only)	Fuel system
12	Intake Air Heater Override	Controls
13	SAE J1939 Datalink Control Test	Controls
14	Setup for Dynamometer	Controls
15	Switch and Sensor Intermittent Connection Test	Controls
16	Starter Lockout Relay Driver Override Test	Controls
17	VGT Electronic Actuator Installation and Calibration	Air Intake and Exhaust
18	**SCR PERFORMANCE TEST**	Aftertreatment
19	**INJECTOR PERFORMANCE TEST (XPI FUEL SYSTEMS)**	Fuel system
20	**ADAPTIVE TRIM**	Fuel system

Adaptive Trim Function for the Injectors (XPI Fuel System Only)

For most injectors previously used on Cummins XPI fuel systems injector trim codes (bar codes) were required.

With CM2350 control system there is no requirement to record and program injector trim code.

ECM has new function to monitor injector performance and compliance with EPA tail pipe exhaust emissions regulations.

How it works? During engine motoring events*,

- Engine motoring event - When you do a throttle snap in the shop or when you are at some road speed and quickly back off the throttle. It only adapts during a motoring event which is no commanded fuel but engine is above idle. Event of any rapid engine speed non-braking deceleration.
- ECM changes injector injection parameters,
- Records change of emissions and performance,
- ECM compares recorded data against pre-programmed parameters ,
- If there is discrepancy found, adjustments are made to injector timing and duration to comply with performance and emissions requirements.

ADAPTIVE TRIM FAILURE CODES

CODE	SENSOR
1139	Injector Solenoid Driver Cylinder 1
1141	Injector Solenoid Driver Cylinder 2
1142	Injector Solenoid Driver Cylinder 3
1143	Injector Solenoid Driver Cylinder 4
1144	Injector Solenoid Driver Cylinder 5
1145	Injector Solenoid Driver Cylinder 6

Fault Codes 1139-1145 are specific to adaptive trim function

Circuit Description

- The ECM uses diagnostic software to verify injector operation. During selected conditions, each injector is fired. The fueling quantity and timing are then compared to a specified threshold.

Conditions for Running the Diagnostics

- This diagnostic runs periodically during engine operation.

Conditions for Setting the Fault Codes

- The Engine Control Module (ECM) detected a fueling timing or quantity error for the specified injector.

Shop Talk

- This fault code is intended to identify fueling quantity and timing issues.

FUEL INJECTOR PERFORMANCE TEST

Fuel Injector Performance Test

- TSB120217
- Similar to the Cut-Out Test or Cylinder Performance Test
- Test will increase engine rpm to a specified value and then perform a number of engine decelerations
- During engine decelerations, fuel pressure stability is verified, fuel pressure drop is monitored, fuel injectors are fired, and fuel injector operation is evaluated
- At the conclusion of the test, the engine will return to idle and suspect fuel injectors will be identified as either a pass or fail

This test originally was released on July 16 2012 for production and service

- HD Engine serial number (ESN) first is 79598702

Engine is experiencing a performance issue that would require fuel injector diagnostics

- Black smoke
- White smoke
- Frequent regenerations
- Rough running
- Misfire
- Fault Codes 3375 and 3376
- Any time the cylinder cut-out test would be run

What's required to Run Test

- Requires latest calibrations
- INSITE™ electronic service tool version 7.6.0 or later

FUEL INJECTOR PERFORMANCE TEST

INSITE Pass/Fail Criteria based on four test points for each injector

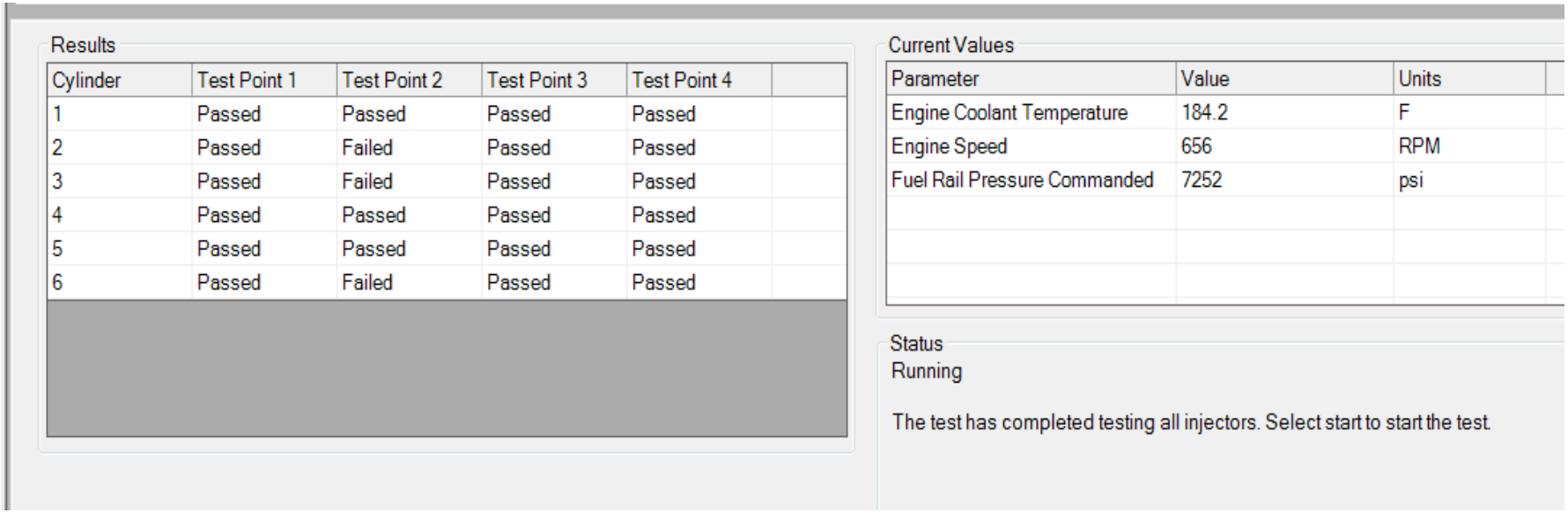
Test 1 1800 RPM 2100 Bar (30457 PSI) fuel pressure simulated idle condition

Test 2 1800 RPM 2100 Bar (30457 PSI) fuel pressure full load/cruise condition

Test 3 1800 RPM 2100 Bar (30457 PSI) fuel pressure full load rated speed condition

Test 4 1800 RPM 500 Bar (7251 PSI) fuel pressure true idle condition

Based on this test which injectors need to be replaced???



Results

Cylinder	Test Point 1	Test Point 2	Test Point 3	Test Point 4
1	Passed	Passed	Passed	Passed
2	Passed	Failed	Passed	Passed
3	Passed	Failed	Passed	Passed
4	Passed	Passed	Passed	Passed
5	Passed	Passed	Passed	Passed
6	Passed	Failed	Passed	Passed

Current Values

Parameter	Value	Units
Engine Coolant Temperature	184.2	F
Engine Speed	656	RPM
Fuel Rail Pressure Commanded	7252	psi

Status

Running

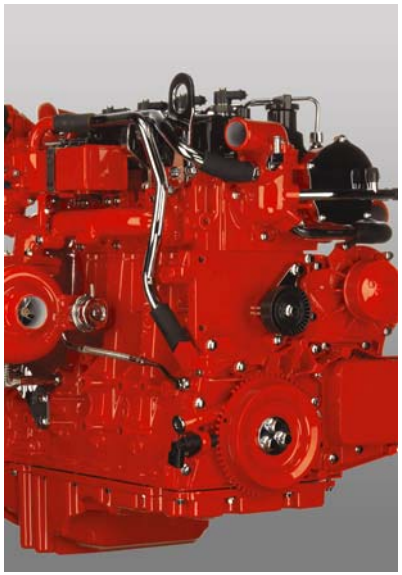
The test has completed testing all injectors. Select start to start the test.

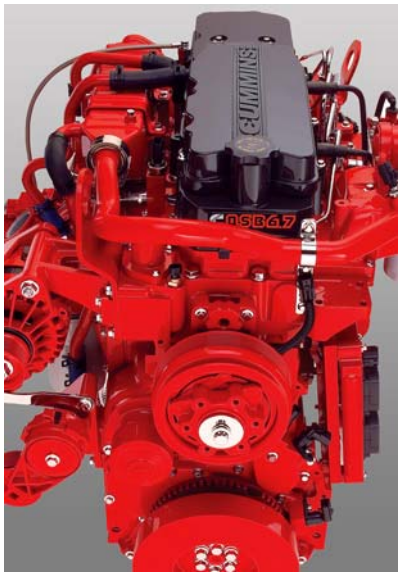
SHOP exercises

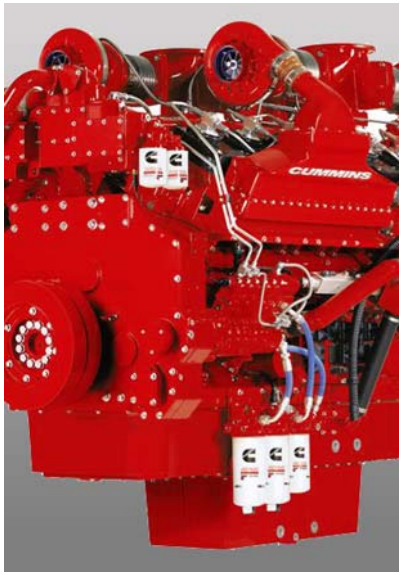
1. **PERFORM NEW INSITE TESTS FOR BASE ENGINE**

2. **96 WAY CONNECTOR EXERCISE**

96 way connector Service







96 – Way Connector